USER'S HANDBOOK

1065

datron

digital multimeter

USER'S HANDBOOK

for

THE DATRON AUTOCAL 1065 DIGITAL VOLTMETER

(for maintenance procedures
refer to the Calibration and Servicing Handbook)

850041 **Issue 1 (SEPT. 1980)**

MP MASTER
MA23497

For any assistance contact your nearest Datron Sales and Service office.
Addresses can be found at the back of this manual.

Due to our policy of continuously updating our products, this manual may contain minor differences in specification, components and circuit design to the instrument actually supplied. Amendment sheets precisely matched to your instrument serial number are available on request.

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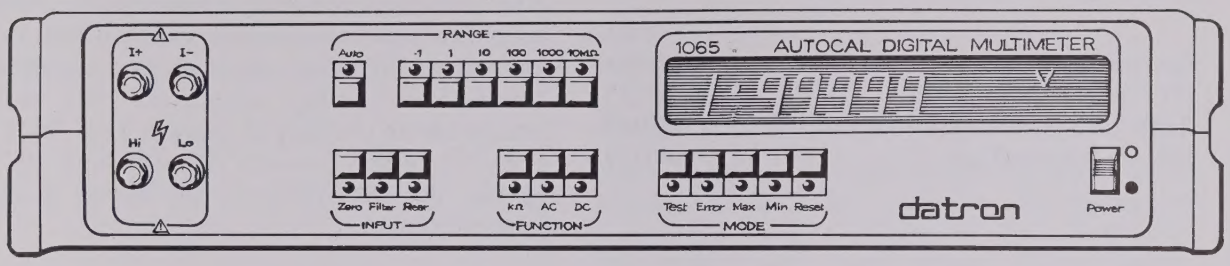
SECTION 1 THE 1065 AUTOCAL INSTRUMENT



The Datron 1065 AUTOCAL multifunction microprocessor controlled digital voltmeter (DVM) is a precision measuring instrument featuring high stability and systems capability. The instrument provides full DC, true RMS AC, and resistance measurement capability on a $5^1/_2$ digit display, together with self check routines and calibration memory.

Standard and optional facilities

The instrument is supplied in one of two configurations:

- DC measurement with the IEEE 488 standard digital interface.
- DC, resistance, true RMS AC voltage, DC coupled true RMS AC voltage with the IEEE 488 standard digital interface.

In addition, for various line supplies and rack mounting, the following options are available.

Option 80: 115V 60Hz line operation
Option 81: 115V 50Hz line operation
Option 82: 115V 400Hz line operation
Option 90: Rack mounting kit

Calibration

The AUTOCAL instruments have been designed to make the removal of the covers for calibration unnecessary, as full calibration of all ranges and functions can be carried out from the front panel.

The procedure for calibrating the instrument is contained in the Calibration and Servicing Handbook.

Accidental or unauthorised use of the calibration routine is prevented by a key operated switch on the instrument rear panel.

Message read-out

The measurement display doubles as a message display, providing a clear read-out of 15 different messages. Full details of the meanings of these displays can be found in sections 2 and 3.

Self test

Pressing the 'Test' key starts a self test procedure, during which a sequential routine:

- checks, in turn, all the display segments characters and legends
- verifies the correct functioning of individual measuring circuits
- checks the non-volatile calibration memory

On completion of the test, the instrument returns to the last selected function and range to provide rapid return to measurement. In the event of the self test failing, an error message is displayed.

Systems use

The AUTOCAL 1065 instrument can form part of a system by means of the IEEE 488 standard digital interface. The details for the connections of the instrument to the system and programming details for the controlling machine can be found in section 4.

Accessories

The instrument is supplied with the following accessories:

Description	Part Number
Power cable	920012
Set of calibration keys	700068
User's Handbook	850041
Calibration and Servicing Handbook	850047

In addition, the following accessories are available for use with the 1065 instrument:

Description	Part Number
HVP high voltage probe	400335
RMK rack mounting kit (option 90)	440063
1501 de luxe lead kit	440070

Additional documentation

The Calibration and Servicing Handbook contains information required to adjust and service the DVM. It contains detailed description of the circuits, trouble shooting diagrams, calibration procedures, parts lists and circuit diagrams.

Principles of operation

Figure 1.1 shows how the DVM achieves its basic measurement functions, its advanced measurement and computing functions and the interfacing with other equipment in systems applications.

Voltage measurement

The instrument comprises a fully floating isolation amplifier with electronically switched gain ranges providing a full range output which is applied to the analog to digital converter. AC voltage measurement is achieved using a True RMS AC converter which converts AC signals to DC and applies the DC voltage to the analog to digital converter.

Resistance measurement

Resistance measurement is achieved by passing the current from an internal precision current source through the unknown resistance and sensing the voltage developed across the resistance.

Analog to digital conversion

The signal from the DC isolator or AC converter is applied to the input of a high gain integration amplifier. The integration capacitor starts charging from a zero state at a rate proportional to the magnitude of the incoming signal. The integration period is approximately 20mS (50Hz) or 16.6mS (60Hz).

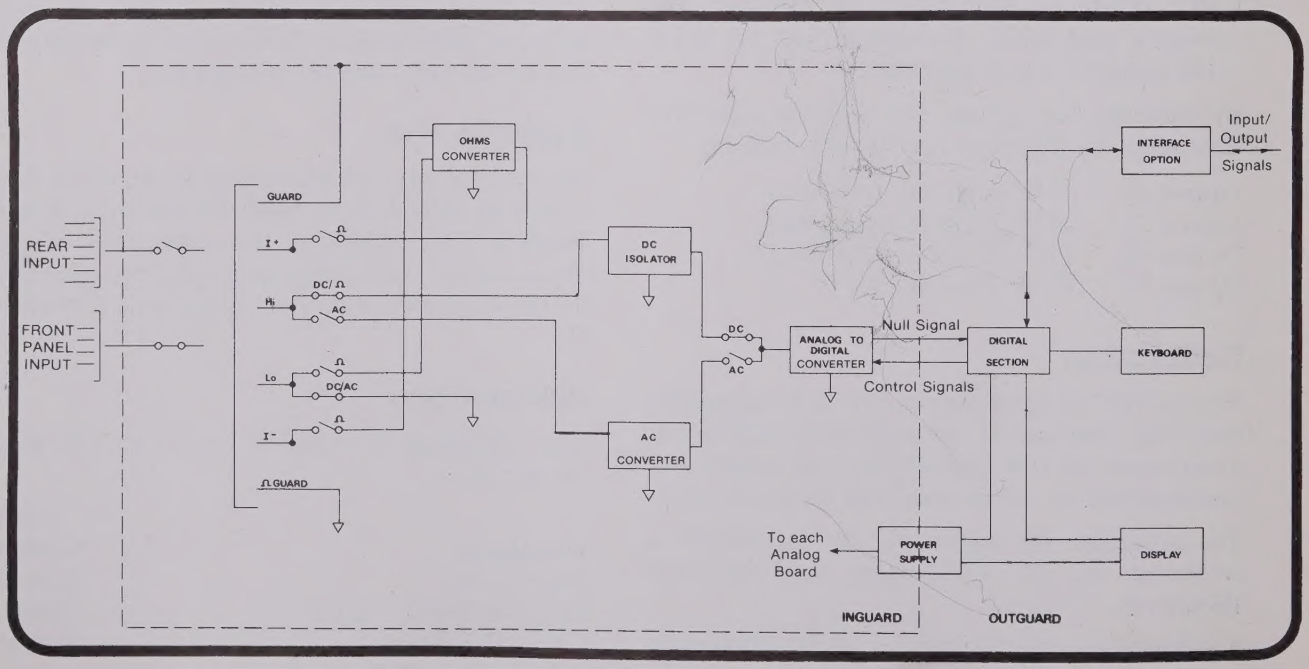


Fig. 1.1 DVM simplified block diagram

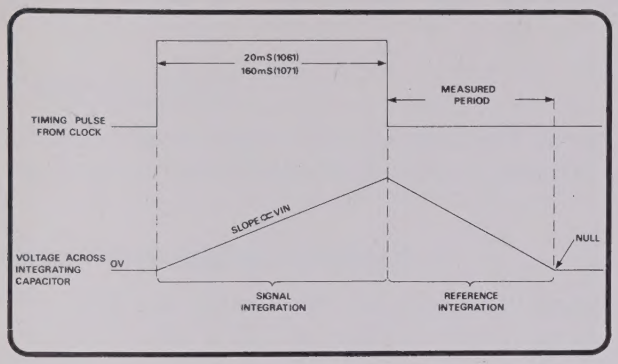


Fig. 1.2 Simplified measurement cycle

At the end of this period, a reference signal of opposite polarity to the input signal is applied and the time taken for the capacitor to discharge to zero volts is measured (null detection), providing an accurate computation of the input signal magnitude.

Processor

The internal control of the instrument is performed by a microprocessor (6800 series) using 8k bytes of program memory. The microprocessor translates range and function information from the front panel keys (or remote source) into commands for the analog sections, generates triggers to control the analog to digital conversion and organises the mode and compute facilities.

Autocalibration

With the calibration enable switch on the rear panel turned to the 'CAL' position, the calibration procedure (see Calibration and Servicing Handbook) can take place, during which measurements of zero, linearity, gain and high frequency gain of the instrument are taken and the results stored in a non-volatile memory. These values are then used as a reference for future measurements when the instrument is in the normal 'RUN' mode.

Error readout

A table of the instrument's measurement specification is held internally, in a read-only memory. When the 'Error' key is depressed, the maximum specified limits of uncertainty for the selected measurement will be displayed according to the measurement and range selected and the position of the calibration interval switch on the rear panel.

SECTION 2 BASIC MEASUREMENT PROCEDURES

Preliminaries

Before using the instrument it is important that it has been correctly installed as detailed in section 5.

Maximum input voltages

The following tables give the maximum input voltages to the DVM for each of the operating ranges.

Normally, inputs are applied to the 'Hi', 'Lo', I+ and I— front panel terminals. When the 'Rear' key is pressed, inputs may be connected to the rear panel input plug where a Guard and Ω Guard connection is also available. For rear panel inputs, maximum inputs indicated at 1000V or 650V RMS must be reduced to 250V RMS.

When the front panel terminals are in use the internal guard screens are internally connected to the 'Lo' terminal for voltage measurement and to Ω Guard for resistance measurement. The 'I+' terminal is internally linked to the 'Hi' terminal and the 'I—' terminal to the 'Lo' terminal via ptc thermistors.

The ⚠ symbol is used to remind the user of special precautions detailed in this Handbook and is placed adjacent to terminals and switches that are sensitive to overvoltage conditions.

DC & AC Voltage

Hi	Lo	I^+	I^-	GUARD	Ω's GUARD	EARTH	
1,000V							
250V	1,000V						
1,000V	250V	1,000V					
1,000V	250V	1,000V	250V				
1,000V	0V	1,000V	250V	250V			
1,000V	650V	1,000V	650V	650V [c]	650V		
1,000V	650V	1,000V	650V	650V [c]	650V	30V [b]	DIG COMMON

Table 2.1 Maximum RMS input voltages (a)

Resistance

HI	Lo	I^+	I^-	GUARD	Ω's GUARD	EARTH	
250V							
250V	250V						
250V	250V	250V					
250V	250V	250V	250V				
250V	250V	250V	250V	250V			
1,000V	650V	1,000V	650V	650V [c]	650V		
1,000V	650V	1,000V	650V	650V [c]	650V	30V [b]	DIG COMMON

Table 2.2 Maximum RMS input voltages (a)

NOTES:

a) Values specified assume peak voltage ⩽ RMS voltage x $\sqrt{2}$. Also Maximum inputs of 1000 or 650V RMS reduce to 250V RMS for rear input.

Maximum permissible voltage between front and rear inputs is equal to the maximum input at the front input (not switched) or 250V RMS (switched).

b) The digital common conductor for the remote interface is internally referenced to earth (ground) via a 100kΩ resistor.

c) Maximum slew-rate of 'Guard' with respect to earth (ground) or digital common ⩽ 50V/ μS (5 x 10^6 volt Hz) for normal operation (accuracy is degraded as volt Hz product increases).

d) Maximum slew-rate of any terminal to earth (ground) should be ⩽ 1kV/ μS (10^8 volt Hz) or the instrument may revert to the 'power up' condition (i.e. select DC 1000V range).

Safety

The 1065 voltmeter is designed to be Class 1 equipment as defined in IEC Publication 348 and UL 1244 concerning safety requirements. Protection is assured by a direct connection via the power cable from earth (ground) to exposed metal parts and internal earth screens.
The line connection must only be inserted in a socket outlet provided with a protective earth contact and continuity of the earth conductor must be assured between the socket and the instrument.

WARNING:

ANY INTERRUPTION OF THE PROTECTIVE EARTH CONDUCTOR INSIDE OR OUTSIDE THE INSTRUMENT OR DISCONNECTION OF THE PROTECTIVE EARTH TERMINAL MAY MAKE THE APPARATUS DANGEROUS. INTENTIONAL INTERRUPTION IS PROHIBITED.

THE TERMINALS MARKED WITH THE ϟ SYMBOL CARRY THE POTENTIAL OF THE SOURCE UNDER TEST. THESE TERMINALS AND ANY OTHER CONNECTIONS TO THE SOURCE COULD CARRY LETHAL VOLTAGES. AT NO TIME SHOULD THESE CONDUCTORS BE TOUCHED DURING A TEST OF HIGH VOLTAGES. IF DIFFICULTY IS FOUND WITH THE TEST, ENSURE THAT THE SOURCE IS RENDERED SAFE BEFORE ATTEMPTING TO IMPROVE CONNECTIONS.

Controls

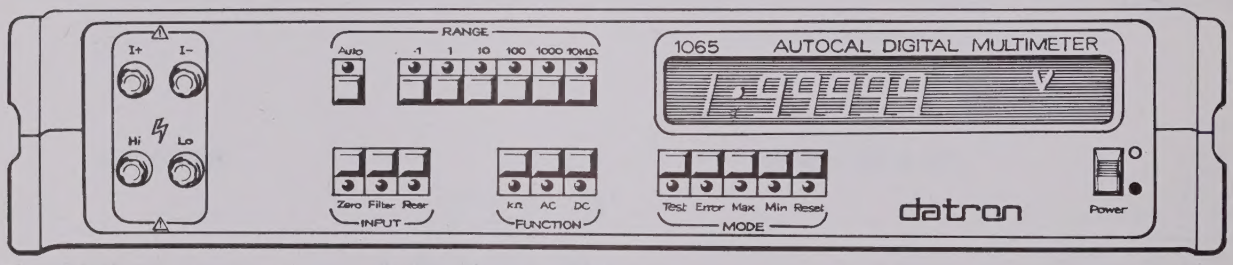


Fig. 2.1 Front panel

Line on/off ('Power') switch

When set to the off position, this switch isolates the instrument from the line supply. When switched to the on position, the instrument powers up and automatically selects its DC 1000V range.

After $^1/_2$ hour, the instrument is near its full specification, but should be left on for 2 hours before use if full accuracy is required.

Function keys

The three keys - 'kΩ', 'AC' and 'DC' - provide the means to select the mode of operation of the instrument and contain LED indicators that light to show the selected function.

'Zero' key. This key enables the instrument to be automatically adjusted to display zero for a zero input signal applied to all ranges of DC volts and Ohms.
In conjunction with the 'Auto' key, the 'Zero' key initiates a zero adjust routine for all ranges.

'Filter' key. The 'Filter' key is pressed to increase the series mode AC noise rejection in measurement of DC volts or resistance and to extend the frequency response of the instrument to make possible AC measurements as low as 45 Hz.

'Rear' key. This key is used to select the rear measurement input plug in favour of the front panel terminals.

Range select keys

The instrument range of inputs in each function is as follows:

1uV	- 1,000V DC
10μV	- 1,000V true RMS AC
1mΩ	- 20MΩ

Autorange ('Auto') key. This key commands the instrument to select the optimum ranges for the measurement, saving the operator this task and introducing very little delay.

Mode keys

The function of these keys is given in Section 3.

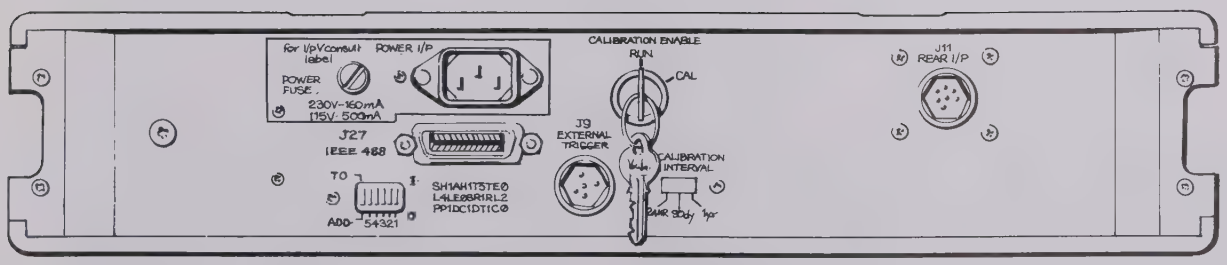


Fig. 2.2 Rear panel

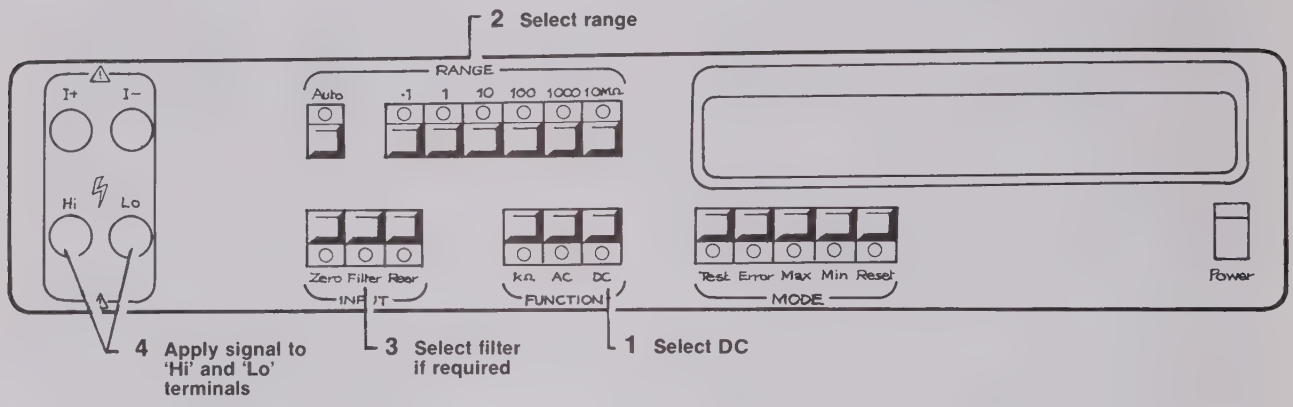
Calibration enable keyswitch

The calibration procedure is detailed in the Calibration and Servicing Handbook. The calibration switch is of the locking type to avoid accidental or unauthorised initiation of the calibration procedure.

Calibration interval switch

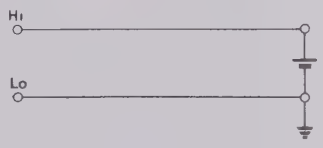
The calibration interval switch should be set to correspond with the intervals that elapse between re-calibrations of the DVM. The setting of the switch determines the selection of error values displayed when the 'Error' key is pressed (see Section 3 - Error mode).

DC voltage measurement procedure



Simple lead connection

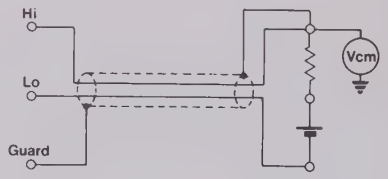
For the majority of applications the simple lead connection shown below will be adequate. The disadvantage of this simple arrangement is that the connection leads form a loop. If a stray alternating magnetic field, e.g. from the line transformer of a neighbouring instrument, passes through the loop it will behave as a single turn secondary winding inducing unwanted AC voltages into the measuring circuit. Use of a twisted pair will reduce the loop area as adjacent twists will automatically cancel any induced voltages. If problems with stray pick-up are encountered it is recommended that a screened twisted pair cable be used with the screen connected to the 'Lo' terminal.

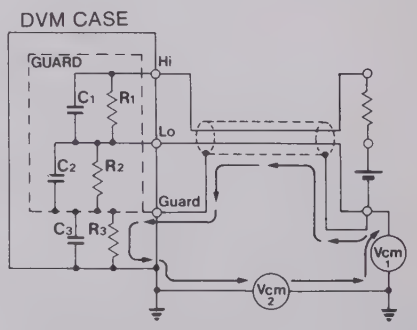


Use of the guard connection

When the front panel terminals are being used, the guard is internally connected to the 'Lo' terminal. When 'Rear' is selected and inputs are taken to rear panel plug, a separate connection is available for guard. If the simple arrangement shown above is adequate, then the guard pin should be externally connected to the 'Lo' pin.

When the source to be measured presents an unbalanced impedance to the measuring input and common mode voltages are present, the Guard pin should be taken to the source of the common mode voltage. This will ensure that errors,caused by common mode currents flowing in the measuring circuits, are minimised by providing a separate common mode current path as shown in the examples below.

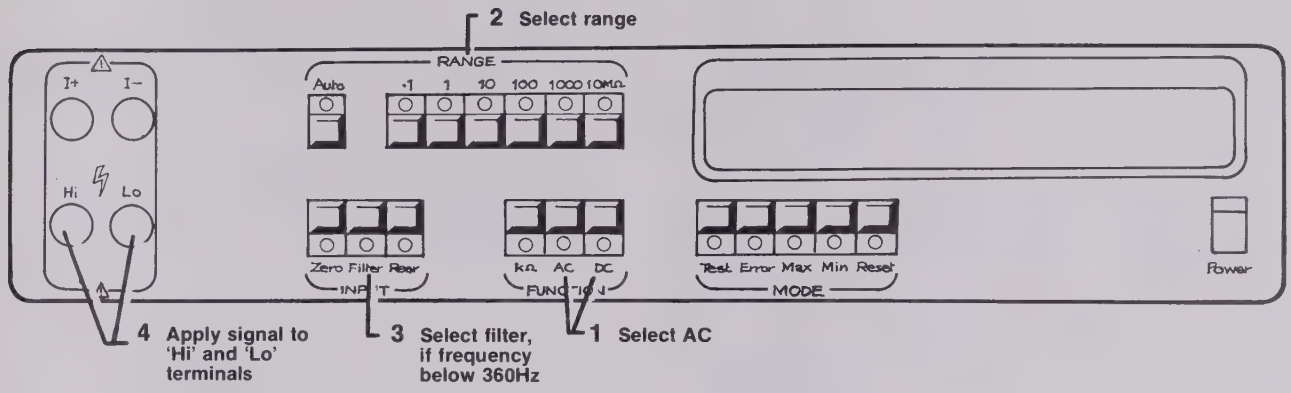




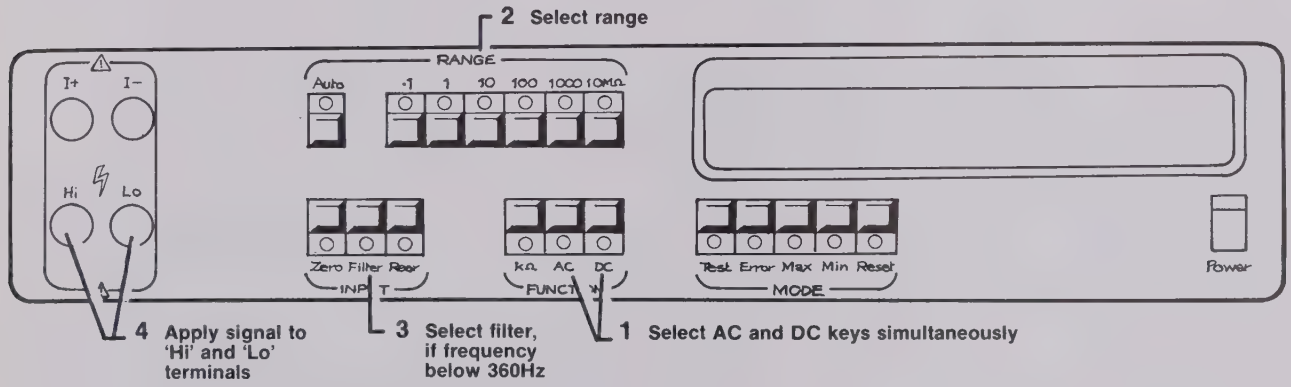
Examples using the Guard connection on the Rear Input plug.

R1, C1 = Input impedance
R2, C2 = Input to guard leakage impedance
R3, C3 = Guard to case leakage impedance
Vcm1, Vcm2= Common mode voltages

AC voltage measurement procedure



DC coupled AC voltage measurement procedure



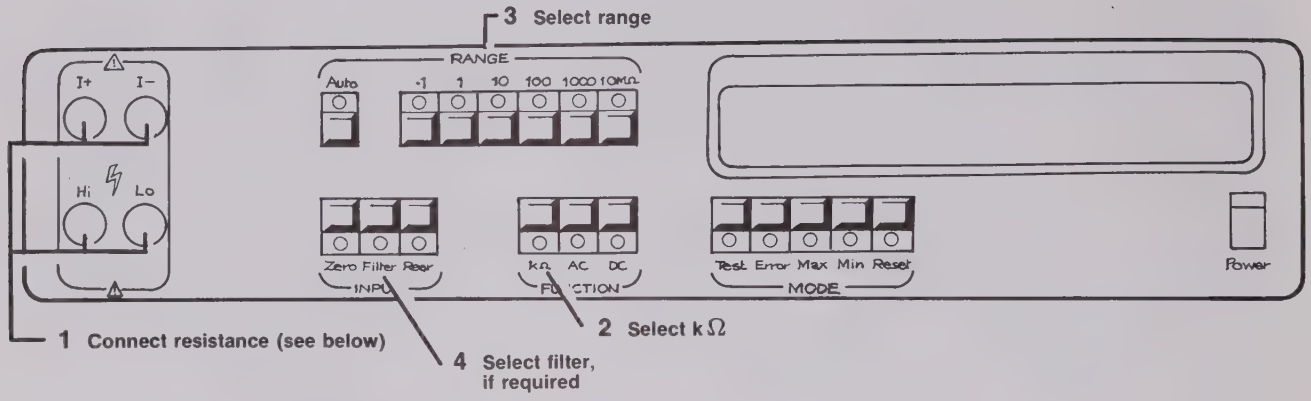
AC voltage measurement

Whilst for DC voltage measurement the resistance of the connection lead is generally unimportant so long as it is small compared with the input impedance of the measuring device, with AC voltage measurement the capacitance may give rise to an appreciable shunting effect causing source loading as well as voltage drop in the leads. The approximate 'Hi' to 'Lo' capacitance of the leads in the Datron lead kit are, low thermal emf lead with spade terminals:— 65pF, other leads:— 160pF. In extreme cases use of separate leads will give lower capacitance (dependent upon spacing but typically 4pF) but will be liable to corrupt the measurement by adding induced signals. The table below gives the approximate impedances at different frequencies.

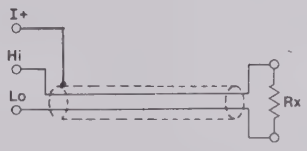
FREQUENCY	LEAD CAPACITANCE		
	4pF	65pF	160pF
100Hz	400MΩ	20MΩ	10MΩ
1kHz	40MΩ	2MΩ	1MΩ
10kHz	4MΩ	200kΩ	100kΩ
100kHz	400kΩ	20kΩ	10kΩ
1MHz	40kΩ	2kΩ	1kΩ

Table 2.4 Connection lead capacitance

Resistance measurement procedure



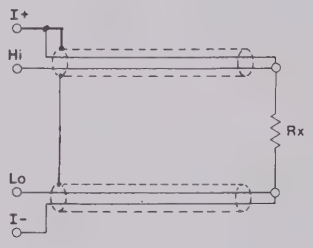
2-wire measurements



For the majority of applications, the simple 2-wire arrangement will be adequate. However, the value displayed will include the resistance of the connecting leads.

Use a screened twisted pair cable to reduce induced voltages, particularly where Rx is high.

4-wire measurements



With a 4-wire connection the lead resistances have negligible effect and only the value of Rx is displayed. The 4-wire connection as shown above using two screened twisted pair cables, is also suitable for measuring high resistances with long cables since the effects of leakage and capacitance between leads is eliminated.

True 4-wire zero

For accurate measurements of resistance it is ESSENTIAL that a correctly connected zero source is used when operating 'Zero' before making a series of resistance measurements.

Two arrangements are shown below, depending upon the resistance to be measured, which ensure that any thermal emf effects are eliminated.

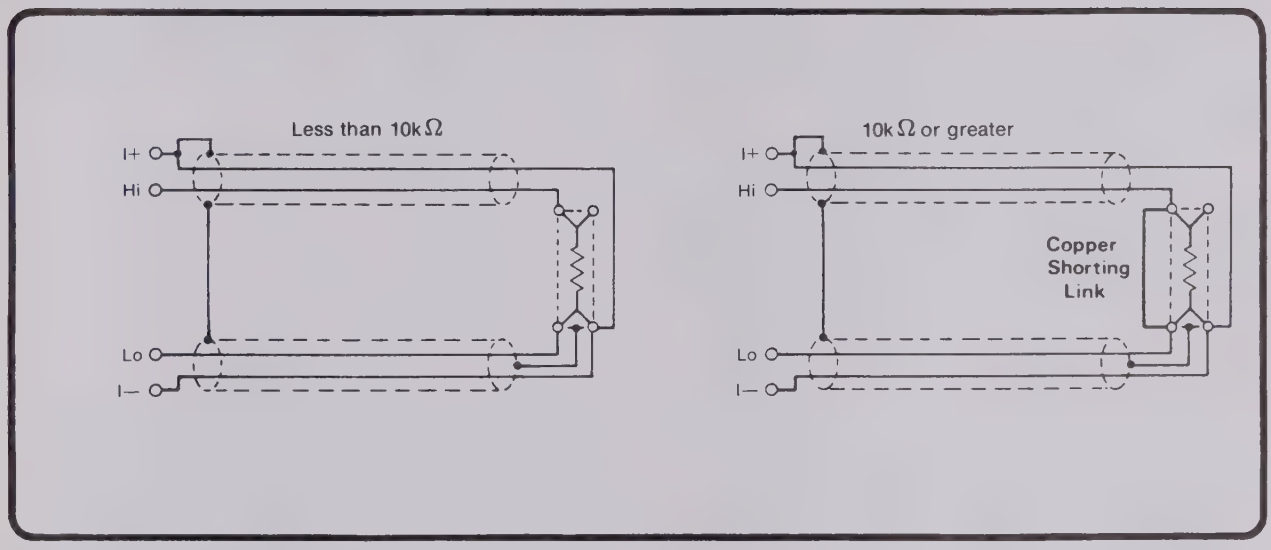


Fig. 2.3 Zero resistance source connections

'In-circuit' measurements

When the resistance to be measured is connected to the rear panel plug, ' Ω Guard' connection is also available.

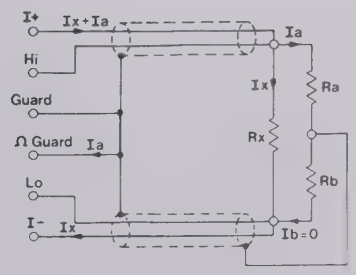
' Ω Guard' can be used to make 'in-circuit' resistance measurements by guarding out parallel resistance paths so that only the value of Rx will be displayed.

Similarly, ' Ω Guard' can be used to reduce the settling time if Rx is shunted by any capacitance and a suitable tapping point is available.

Providing Ra and Rb are no less than 500Ω the error will be:

$$\frac{10^6\ RxRb}{RxRg+RaRb} \quad \pm K\left(1+\frac{Rx}{Rb}\right) \text{ ppm of reading.}$$

Where K = 100 (100Ω range)
or K = 10 (all other ranges)
Rg = Ω Guard lead resistance from junction of Ra & Rb + 0.25Ω



Rear input

Any voltage or resistance source to be measured may be connected to the 'REAR I/P' plug instead of the front panel terminals when 'Rear' is selected on the front panel.

For all rear panel inputs, the maximum input limit is 250V RMS.

When using the 'REAR I/P' plug a connection must ALWAYS be made to the 'Guard' pin H. In most cases it is adequate to connect this to the 'Lo' pin; otherwise it should be connected as described in the DC voltage measurment procedure.

For resistance measurements (including 2-wire), connections must ALWAYS be made to all pins 'Hi', 'Lo', I+, I—, Guard and Ω Guard. In most cases it is adequate to connect 'Guard' to ' Ω Guard' only.

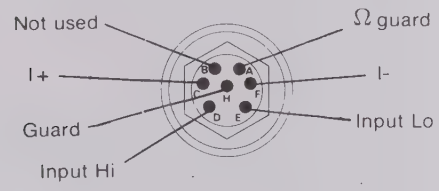


Fig. 2.4 Rear input 7 pin plug

Thermal EMF

Thermal emfs can be significant in DC voltage and resistance measurements, especially when measuring low voltages. These unpredictable thermal emf errors arise when dissimilar metal junctions are at different temperatures. To minimise thermal emf errors use the same material throughout the measuring circuit, particularly avoid the use of steel probes, nickel plated terminals and tinned copper wire. The table below shows thermal emfs relative to hard drawn copper at 23°C.

MATERIAL	EMF μV/°C
SILVER	+0.03
GOLD	+0.01
TIN	−3
LEAD	−3
NICKEL	−22

If dissimilar metal junctions are used ensure that they are offset by other junctions of the same material at the same temperature and allow for thermal emfs by making the measurement twice with reversed polarities.

A lead with gold plated copper terminals is provided in the Datron lead kit for making low thermal emf connections.

Display messages

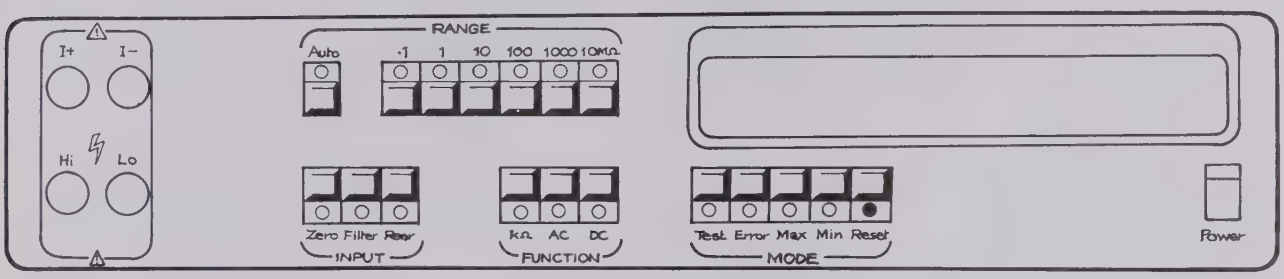
Alpha numeric messages will appear on the display when an input or memory error occurs. Messages will also appear during the self test routine.

Message	Cause	Correction
Err OL	Overload 199999	Reduce input signal or up range
Err 1	Arithmetic Overflow	
Err 2	Invalid Data Entry/Recall	Adjust Data value/Recall
Err 3	Error > 100% or unspecified	
Err 4	Zero or calibration input error	Adjust applied input and repress key
Err 5	DC Self Test failure	Refer to Calibration and Servicing Handbook
Err 6	kΩ Self Test failure	
Err 7	AC Self Test failure	
Err 9	Arithmetic Underflow	
Err Lt	High and Low Limit transgressed	Amend limit values
Hi Lt	High Limit transgressed	
Lo Lt	Low Limit transgressed	
IP·O	Zero memory error	Repeat input zero procedure
FAIL	Calibration memory error	Refer to Calibration and Servicing Handbook
PASS & Legend	Self Test pass message	

SECTION 3 ADVANCED OPERATIONAL PROCEDURES

The procedures for exercising the features that supplement the basic measurement functions of the 1065 AUTOCAL instrument are detailed in this section.

External triggers and 'Reset'



When the instrument is under local control, readings are taken at a rate in accordance with its internal read rate specification. When the 'Reset' key is pressed the reading in progress is completed and displayed, but no further readings are taken. This also resets the Max and Min stores.

The DVM measurement cycle can now be triggered externally. The external trigger connector is on the rear panel, connection arrangement is shown in Fig. 3.1.

Pressing 'Reset' again returns the instrument to its free running condition.

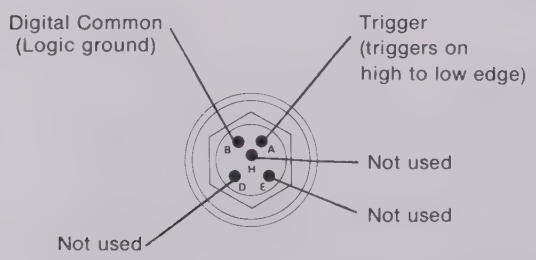
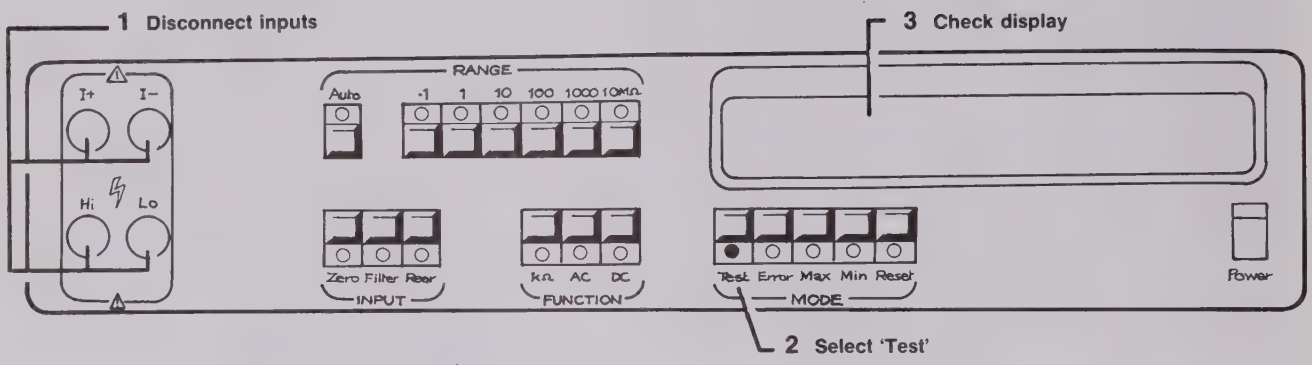


Fig. 3.1 External trigger 5-pin plug

Self test



Pressing the 'Test' key starts a self test routine. The self test is a part visual, part internal check of the proper operation of the instrument. A visual check is made of the display by the operator and internal checks are executed to verify that the circuits are functioning correctly. Self test does not check the full measurement accuracy of the instrument.

ALL FRONT PANEL MEASUREMENT INPUTS SHOULD BE LEFT OPEN CIRCUIT.

Self test sequence

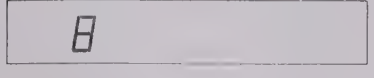
The routine after pressing 'Test' is as follows:

1. Turns off all key LEDs except 'Test'.
2. Display cleared.
3. Seven segment digits and legends illuminated 'bar' by 'bar'.

4. All decimal points displayed.

5. Polarity signs and overrange digit displayed.

6. Seven segment digits displayed digit by digit.



7. First then second block of legends displayed.

8. Display cleared.

Internal check sequence

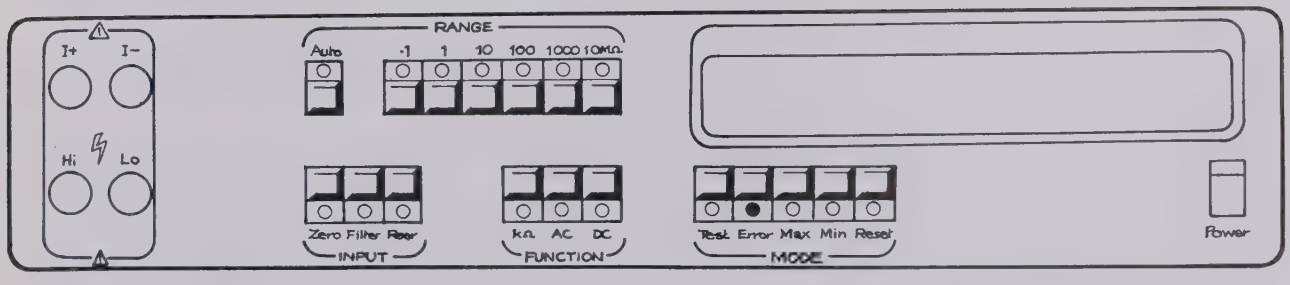
	Pass indication:
9. Check DC volts.	Adds V legend.
10. Check Ohms.	Adds Ω legend.
11. Check AC volts.	Adds ~ legend.
12. A check is made of the non-volatile memory (i.e. the calibration and zero memory).	PASS

When the test routine is completed successfully, the instrument will retain the 'PASS' indication. Pressing 'Reset' will return the instrument to the last selected range and function but all mode functions are cancelled.

When the 'Test' routine finds an error in the internal checks, an Error message will be held on the display. To clear this state and continue with the self test routine, press the 'Test' key again. Refer to Calibration and Servicing Handbook for fault finding procedure.

An Err 5 indicates DC failure
Err 6 indicates kΩ failure
Err 7 indicates AC failure
FAIL indicates Calibration memory error.

Error mode



Depressing the 'Error' key causes the instrument to compute and display an error value that relates to the last measurement made. The instrument contains a table of the measurement specification for every function and range and the maximum limits of uncertainty for the last displayed measurement is displayed as a fraction of that measurement.

The uncertainty is calculated according to the setting of the calibration interval switch on the rear panel so that the instrument's specification is examined in the area that corresponds to the chosen re-calibration interval.

The display is preceded by a +/— indication and is in ppm or %, depending on magnitude. Very large errors, such as near zero readings, are displayed as a message (Err 3).

Depressing the 'Error' key again, returns the instrument to normal operation.

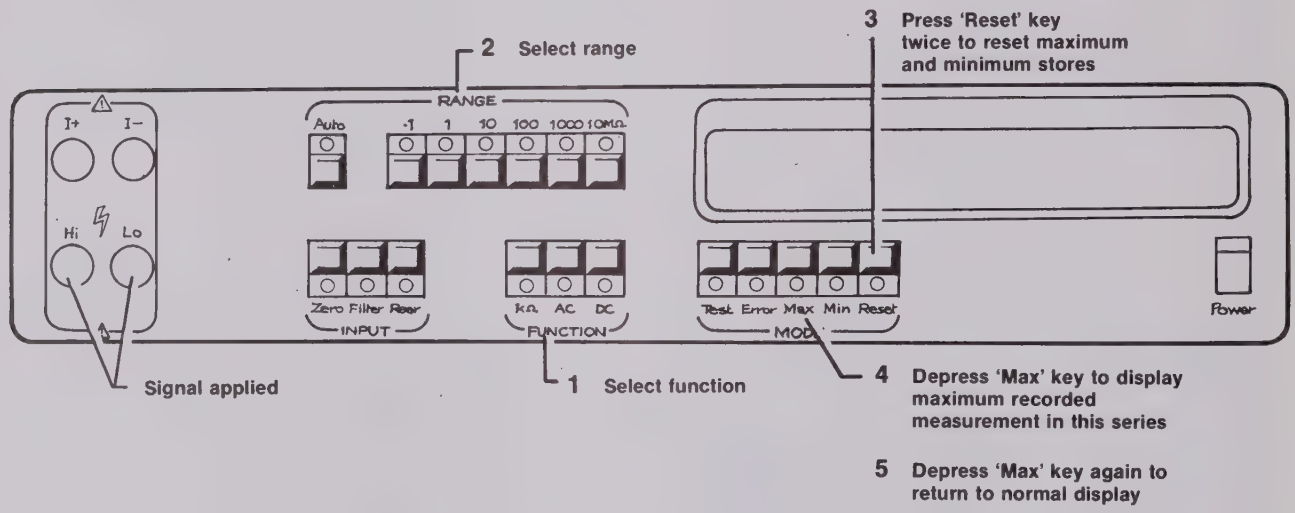
Max and min

Selection of 'Max' or 'Min' causes the display to indicate the maximum or minimum reading since the stores were last reset. Each time the measured value is outside the current maximum or minimum, the appropriate store is updated.

The 'Max' and 'Min' stores are reset by pressing 'Reset' (press twice to return the DVM to its free running condition) or changing function, after which the maximum and minimum displayed values are again retained and updated.

Simultaneous selection of 'Max' and 'Min' gives a maximum-minimum indication, i.e. a peak to peak indication of the readings since the stores were last reset.

Max and Min procedure: Displaying the maximum value of a series of inputs.



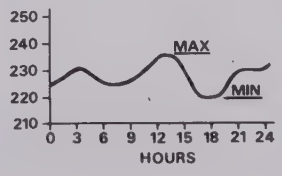
Example of Max and Min measurement

To find the maximum and minimum line supply voltage over 24 hours.

The instrument automatically keeps a record of maximum and minimum readings. Therefore once the DVM has been set to monitor the input voltage (i.e. AC volts, 1000V range, filter in), the run may be started by clearing the stores (press 'Reset' twice).

During the run the instrument can be set to display individual readings, the maximum or the minimum without store corruption.

On completion of the run, selecting 'Max' or 'Min' causes the instrument to display the maximum or minimum readings respectively.



SECTION 4 SYSTEMS APPLICATION VIA THE IEEE INTERFACE

The IEEE interface option allows the 1065 instrument to form part of a system, outputting measurement data to other parts of that system. In addition the DVM can be instructed via the interface to change the mode of operation so that the instrument's facilities can be selected remotely.

In order that instruments from differing manufacturers can be built into the same system, it is necessary that all interfaces are compatible. To ensure this, the interfaces conform to a standard specification as detailed in the publication ANSI/ IEEE Std 488-1978 called 'IEEE Standard Digital Interface for Programmable Instrumentation'.

A typical system is shown in Fig. 4.1. The system is driven by a controlling device able to issue commands (controller), receive data (listener) and output data (talker). The DVM is able to receive programming information (listener) and to output data (talker). A device such as a printer or VDU will simply input data (listener), its output not being into the system, but onto paper or a screen. The signal scanner is also a listener, only receiving commands. Neither its signal input or output are directly connected to the interface bus.

If a system comprises several instruments, the controller is able to communicate with the instruments individually through the assignment to each of a different 'address'. One address is sufficient for each instrument as the controller adds information to the address to define either talk or listen.

In the system example (Fig. 4.1), the sequence of events for the task of selection of one of the input signals, measuring it with the DVM and printing the result, is as follows:

1. The controller needs to select a signal and therefore must send instructions to the scanner. The instruction must not be received by the DVM or the printer and so the controller sends the general bus message "unlisten".
2. To enable the scanner to receive its instructions the controller sends the listen address which has been assigned uniquely to this device. It follows this with the instructions required to select a channel. The instructions are passed along the IEEE bus data lines as coded messages (bytes). The code most normally used is ASCII (American Standard Code for Information Interchange).
3. Since the scanner will take a period of time to change channels it sends a message back to the controller via one of the IEEE bus management lines upon completion. Note that the scanner does not have to be addressed as a talker to return information to the controller via the management lines. This is only necessary if the data lines are to be used.
4. The controller does not know which of the devices generated a message on this management line, since all devices are connected to the same line. To determine the originator, the controller will, by sending messages via the interface, ask or 'poll' all the devices either one by one (serial poll) or together (parallel poll).
5. The controller will determine that the scanner is the source and must send instructions to the DVM so that the correct range and function is selected before the measurement is made. Firstly it must ensure the scanner is not listening since any coded messages sent to the DVM (known as "device dependant") could be misinterpreted by the scanner.

   Sending 'unlisten' followed by the listen address of the DVM and the required programming instructions achieves the desired result.
6. The DVM requires a period of time to take a measurement and prepare data. It generates a message via the same management line (SRQ) to the controller when it is ready.
7. The controller must again determine which of the devices sent the message (service request SRQ) by conducting a poll.
8. With the reading available, the controller activates the printer with its listen address only, and the DVM with its talk address.
9. When the controller signals the beginning of the transfer, using another of the bus management lines, the DVM will send the data byte by byte to the printer using the three

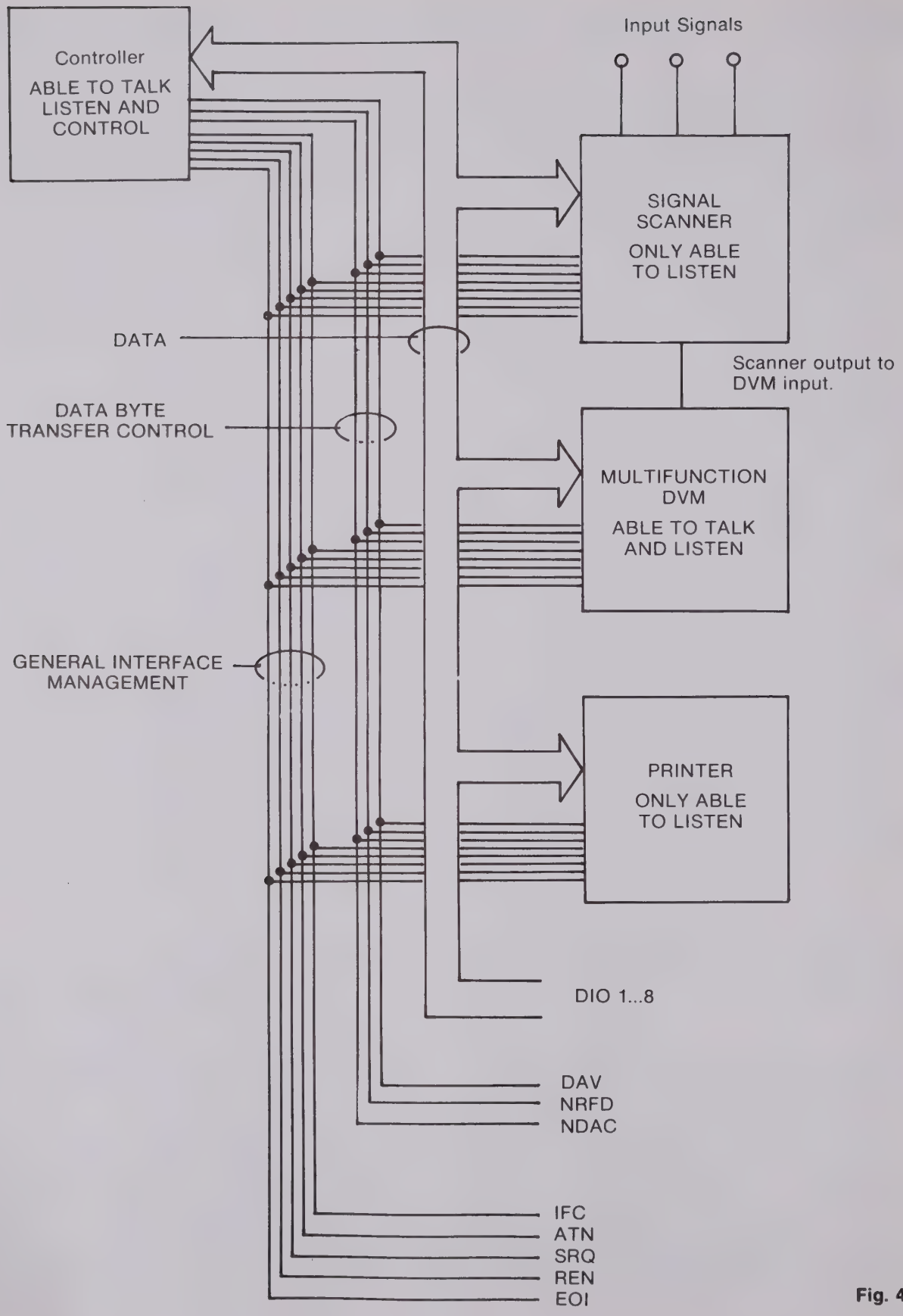

Controller
ABLE TO TALK
LISTEN AND
CONTROL
Input Signals
SIGNAL
SCANNER
ONLY ABLE
TO LISTEN
DATA
Scanner output to
DVM input.
DATA BYTE
TRANSFER CONTROL
MULTIFUNCTION
DVM
ABLE TO TALK
AND LISTEN
GENERAL INTERFACE
MANAGEMENT
PRINTER
ONLY ABLE
TO LISTEN
DIO 1...8
DAV
NRFD
NDAC
IFC
ATN
SRQ
REN
EOI

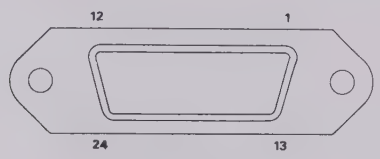
Fig. 4.1

data byte transfer control lines (handshake lines) to ensure orderly transfer of data between the instruments.

10. Usually the controller is also listening to this data transfer to determine when it is complete. As an aid to the controller and printer, the DVM will send with the last byte to be transferred another message (EOI end or identify) using another of the bus management lines.

11. The sequence is complete and the controller is able to start again using another input signal.

Connecting the 1065 into a system



24-PIN SOCKET
IEEE 488/1978 INTERFACE
INPUT/OUTPUT

Fig. 4.2

J27 Pin No.	Name	Description
1	DIO 1	Data Input Output Line 1
2	DIO 2	Data Input Output Line 2
3	DIO 3	Data Input Output Line 3
4	DIO 4	Data Input Output Line 4
5	EOI	End of Identify
6	DAV	Data Valid
7	NRFD	Not ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening on cable - connected to DVM logic gnd.
13	DIO 5	Data Input Output Line 5
14	DIO 6	Data Input Output Line 6
15	DIO 7	Data Input Output Line 7
16	DIO 8	Data Input Output Line 8
17	REN	Remote Enable
18	GND 6	Gnd wire of twisted pair with DAV
19	GND 7	Gnd wire of twisted pair with NRFD
20	GND 8	Gnd wire of twisted pair with NDAC
21	GND 9	Gnd wire of twisted pair with IFC
22	GND 10	Gnd wire of twisted pair with SRQ
23	GND 11	Gnd wire of twisted pair with ATN
24	GND	DVM logic ground

Table 4.1 IEEE 488/1978 Connector - Pin Designations

Interconnections

Instruments fitted with an IEEE interface are connected together to form a system by using an interconnecting cable as specified in the IEEE Standard 488-1978 document. The connector and pin designations are also standardised and shown in Fig. 4.2 and Table 4.1.

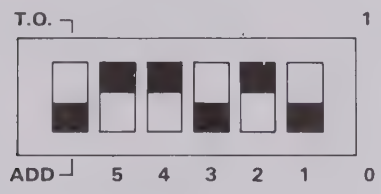
Although the interface specification is called a standard, variations in implementation within the specification are permitted. These variations determine the capabilities of the particular interface and a list of abbreviations are defined in the standard document to indicate to a user which interface capabilities have been designed in. These abbreviations appear on the rear of the instrument beneath the interface connector and are shown in the table below. A fuller description of each code appears in appendix C of the IEEE standard.

Code	Interface Function
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T5	Talker (basic talker, serial poll, talk only mode, unaddressed to talk if addressed to listen)
TEØ	No Address Extension Talker Mode
L4	Listener (basic listener, unaddressed to listen if addressed to talk).
LEØ	No Address Extension Listener Mode
SR1	Service Request Capability
RL2	Remote/Local Capability (without Local Lockout)
PP1	Parallel Poll Capability (configured by the controller)
DC1	Device Clear Capability
DT1	Device Trigger Capability
CØ	No Controller Capability

IEEE Interface capability.

Address selection

The instrument address is set manually using a six way minature switch near the interface connector on the rear panel. Five of the switches are used to set the address, and using a binary code, this enables any address in the range 00 to 30 to be used.
e.g. 11010 is address 26.

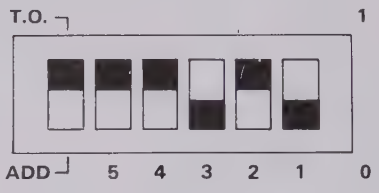


Address Switches					5-bit
A5	A4	A3	A2	A1	Decimal Code
0	0	0	0	0	00
0	0	0	0	1	01
0	0	0	1	0	02
0	0	0	1	1	03
0	0	1	0	0	04
0	0	1	0	1	05
0	0	1	1	0	06
0	0	1	1	1	07
0	1	0	0	0	08
0	1	0	0	1	09
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16
1	0	0	0	1	17
1	0	0	1	0	18
1	0	0	1	1	19
1	0	1	0	0	20
1	0	1	0	1	21
1	0	1	1	0	22
1	0	1	1	1	23
1	1	0	0	0	24
1	1	0	0	1	25
1	1	0	1	0	26
1	1	0	1	1	27
1	1	1	0	0	28
1	1	1	0	1	29
1	1	1	1	0	30

Table 4.2 Address Selection

'Talker only' ('T.O.')

The sixth switch, when set to a "1", causes the DVM to become a 'talker only', meaning it can only output data and not be programmed over the interface. This is particularly useful if, for example, the system consists of only a DVM (the talker) and a printer (the listener), in which case a controller is not required.



Address 31 (Illegal bus address)

The address selected affects the manner in which the DVM powers up.

With address 31 selected, the DVM assumes the role of bench instrument and powers up to DC, 1000V range and reading at the internally controlled read rate. In addition, a manual calibration is only enabled with Address 31 selected, as explained in the Calibration and Servicing Handbook.

With an address selected in the range 0 to 30, the instrument powers up as a systems instrument in DC, 1000V range but in 'Reset'. Each time power-up occurs in this condition, a message is sent to the system controller to indicate that an instrument power-up has taken place.

Using the 1065 in a system

The DVM can be operated under remote control, when ASCII coded programming instructions are received from a controller, or in local control when the DVM is operated from its front/rear controls. In both cases output of results or parameters is available at both DVM display and via the interface.

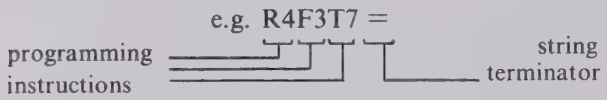
When operating in remote the legend 'rem' is displayed and all front panel controls are disabled except 'Power'.

All the front panel controls (except 'Power'), are programmable via the interface, in addition to 'Run/Cal-Calibration Enable' on the rear panel.

Furthermore, other 1065 features exist which are only programmable and therefore can only be used with the IEEE interface. These are Superfast, Binary Program, Binary Dump and Delay. These are explained in this section of the handbook under 'Programming instructions'.

From the example given earlier in this section it may be seen that the DVM requires an address command followed by a series of device dependant messages or commands to change the various range, function and operating modes.

A series of these commands can be sent together as a 'program string' each programming instruction being position independent.



Each string will contain at least one programming instruction, details of which are given later, but before the instrument can take any action on the instructions, it must receive a terminate signal at the end of any string.

The required terminators are:

i) The ASCII character '='
or ii) EOI (end or identify) with the last byte of the string.

To assist in obtaining a correct set of programming instructions, the DVM checks for errors in the string, and generates a service request (SRQ) if a syntax error occurs or if an option was called for but not fitted.

The full range of commands for programming the DVM is given in Table 4.3. The precise programming details for each command are given in the next section under 'Programming instructions'.

Programming instructions

Control of DVM inputs

Range. R1 through to R7 configure the instrument to a specific range, while RØ places the instrument in auto-range. Programming R7 when Ohms is not selected causes the DVM to set itself to R6.

Function. F1, F2, F3 & F6 configure the instrument to the required function.

Filter. Programming C1 introduces an additional filter into the analog circuitry.

Front/rear input selection. At power up, the DVM selects front input. Selection of front or rear can be accomplished by programming IØ or I1 respectively.

Triggers. A reading may be triggered from one of three sources, (1) internally generated, (2) external (see section 3), (3) a GET (group execute trigger) via the interface. A group execute trigger is a standard bus message which is recognised by the DVM when it has been addressed as a listener. Programming the appropriate trigger code allows one or more of these sources to initiate a measurement cycle. When the DVM is programmed to accept GET, sending the ASCII character @ as part of the program string will also trigger the instrument.

The GET command will initiate a measurement cycle if one is not already in progress or will be stored until the current measurement cycle is complete in order to initiate a second cycle. This permits the second cycle to overlap the processing of data from the previous measurement cycle to increase overall instrument read rate.

In the same way, an external trigger received during the processing of data from an earlier measurement cycle will initiate another measurement cycle. External triggers received during the measurement cycle will be ignored.

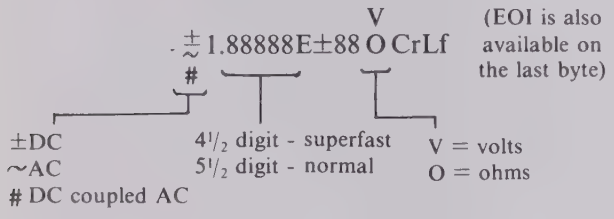
Delay. DX inserts the standard internal delay into the digital circuitry to allow for the settling of analog signals and is dependent upon the function/range/filter combination selected.

D*** (D followed by a number in the range 0-254) inserts a programmable delay.

Delay = (***N) mS
where *** is in the range 0-254
and N = 5 mS

Control of DVM output

Output notation. OØ configures the data to be output as an ASCII character string in scientific notation, with range and function data in the following format:



Programming O1 includes in the output string full instrument status information having the format:

±1.88888E±88 V O ,R4F3NØQ1T3CØDXWØCrLf

(EOI is also available on last byte.)

NOTE: DX will be replaced by D? when using non-standard delays.

Programming O2 or O3, changes the output to four byte binary where the reading is represented as a fraction of full range. Various formats exist to cope with the variable scale lengths and the following equations are provided for translation to decimal numbers assuming the four bytes in order are A B C & D.

Positive readings ($A = \varnothing_{10}$)

Reading =

$$+\left(\frac{B}{32}+\frac{C}{8192}+\frac{D}{2097152}\right) \times \text{Full range}$$

Negative readings ($A = 255_{10}$)

Reading =

$$-\left(\frac{(255-B)}{32}+\frac{(255-C)}{8192}+\frac{(255-D)}{2097152}\right) \times \text{Full range}$$

Superfast positive readings ($B = \varnothing$)

Reading =

$$+\left(\frac{C}{64}+\frac{D}{16384}\right) \times \text{Full range}$$

Superfast negative readings ($B = 255$)

Reading =

$$\left(\frac{255-C}{64}+\frac{255-D}{16384}\right) \times \text{Full range}$$

NOTE:
1. Since byte A is not required for data in superfast mode the instrument status byte is substituted.
2. The most significant byte, i.e. A, is the first byte output.
3. Only EOI is available as a terminator with the last byte in O2 mode. O3 mode has no terminator.
4. Autorange is not recommended in binary output modes.

When the output has been read no further output is available until the data from another measurement cycle has been obtained and processed. If an error occurs during a measurement cycle the normal output is replaced by a message, e.g.:

In OØ and O1 an overload would produce 'ERR OL'

In O2 and O3 any error will produce 255_{10}, i.e. all 1's, in all four bytes, except in superfast when the first byte is always instrument status.

Service request

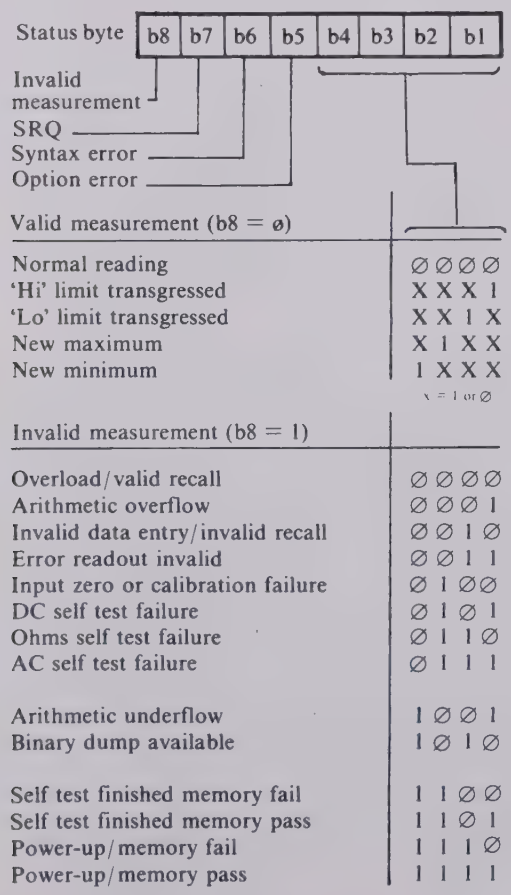
A wide variation can occur in the time taken for a measurement cycle, dependant on factors such as the magnitude of the signal. Therefore, when the result is available, a service request (SRQ) is generated by the DVM via the interface. This can act as a flag (or interrupt) to a controller, which is processing other data, signalling that the DVM requires service.

Q1 and Q3 allow a SRQ to be generated on completion of any reading while Q2 and Q4 allow generation of an SRQ only when a reading is 'out of limits', or when a new maximum or minimum occurs. Programming Q3 or Q4 inhibits further triggers until the DVM has been serviced. An SRQ will always be generated on power up and when a syntax error occurs. Q∅ however, will suppress other SRQ's normally generated.

Serial Poll and Status Byte

In a system with various devices, many of them could request service and to determine which of these devices had initiated a request, either a serial poll or a parallel poll would be undertaken by the controller. During a serial poll each device sends its status byte on command, and the controller checks the request bit, thus determining a requesting device.

The DVM has many reasons for requesting service and with the additional bits available in the status byte this information is also transferred during a serial poll.


Status byte
b8 b7 b6 b5 b4 b3 b2 b1
Invalid measurement
SRQ
Syntax error
Option error
Valid measurement (b8 = ø)
Normal reading ∅∅∅∅
'Hi' limit transgressed X X X 1
'Lo' limit transgressed X X 1 X
New maximum X 1 X X
New minimum 1 X X X
X = 1 or ∅
Invalid measurement (b8 = 1)
Overload/valid recall ∅∅∅∅
Arithmetic overflow ∅∅∅1
Invalid data entry/invalid recall ∅∅1∅
Error readout invalid ∅∅11
Input zero or calibration failure ∅1∅∅
DC self test failure ∅1∅1
Ohms self test failure ∅11∅
AC self test failure ∅111
Arithmetic underflow 1∅∅1
Binary dump available 1∅1∅
Self test finished memory fail 11∅∅
Self test finished memory pass 11∅1
Power-up/memory fail 111∅
Power-up/memory pass 1111

Parallel poll

The parallel poll capability provided for in the DVM allows a controller with similar capability to more quickly determine which device is requesting service. The controller can, at any time. conduct a parallel poll when all devices, which have been configured to respond, will place on separate bus data lines a positive poll response if the device was requesting service or a negative poll response if the device does not require service. With eight data lines available the controller can simultaneously check eight responses.

Having determined the requesting devices from the parallel poll the controller would normally conduct a serial poll of these devices to determine the reason for the request.

The configuration of a device to respond to a parallel poll consists of determining the DIO line on which the response will occur and the sense (∅ or 1) of the positive poll response. The negative poll response gives the opposite sense. The DVM can only be configured for this response by the controller. The configuration sequence is given later in this section.

The DVM must be serviced by either reading the output or by reprogramming to allow the generation of subsequent service requests.

To aid the user in servicing the instrument by reading, a character string is always available for output on generation of an SRQ even if a measurement is not available. This string in O∅ and O1 modes is "!CrLf" and in O2 and O3 modes all four bytes contain 255_{10} (all 1's). These 'null' strings occur with syntax or option programming errors if no measurement is available.

Control of limits & max/min

High or low limit values may be placed into two limit stores so that when these values are transgressed by a later reading the appropriate bit is placed in the SRQ status byte. Limit displays are as described in Display messages, section 2.

Keyboard. The limits are entered by placing the DVM into keyboard mode with a K followed by the limit value. This value may be expressed in numeric or scientific notation as ±1.88888±(Ø)8. If a two digit exponent is used the first must be zero. The constant entered is not shown on the front panel display.

Store. The limit value should be followed by either L3 for High Limit or L4 for Low Limit. This stores the value for comparison with next valid measurement.

e.g. To store a limit of +6 Volts in the high limit store the following string could be used:

KØ.6E+Ø1 L3

LØ deselects limits operation and also resets max/min stores. A new max/min value will be stored on completion of next valid reading.

Recall stores. The current contents of the two stores can be displayed on the front panel and output via the bus with the commands V3 & V4 having the format:

±1.88888E±88L2CrLf.
store location

NOTE:
1. The output of the stores is not available in binary output modes.
2. It is recommended that after the recall of a store value the trigger mode is reprogrammed.
3. Recall of empty limit stores will result in ERR2 being output.

Max/min. The maximum or minimum reading since the stores were last reset is output in place of the current reading wheen N1 or N2 are programmed. N3 computes the difference between maximum and NØ places the instrument back to its normal operating mode. Reset of stores occurs automatically on changing function and entry or exit from superfast mode and programming LØ.

Alternative method of programming

Binary program. Using only four bytes the majority of instrument functions may be programmed. The first of the group must be an ASCII 'B' followed by three bytes containing programming information in the following format. In this programming mode the terminator must be an EOI as the "=" character is not recognised.

	bit							
	b8	b7	b6	b5	b4	b3	b2	b1
byte 1	output notation		function			range		
byte 2	not used		service request			Superfast		not used
byte 3	filter	trigger			Max/Min		not used	

Each group of bits is replaced by the binary equivalent of the numeric value used for normal programming. Thus to program DCV (F3) by binary programming, byte 1 bits 6,5,4 are Ø11 respectively.

Example:
To program scientific output notation with full status, DC Voltage, 10V range, generation of SRQ on data ready for output, not superfast, filter, GET and not max/min mode. The normal string to set the instrument to the above status is O1F3R4Q1SØC1T2NØ. (This string could be shorter by programming only those controls that need updating.)

The equivalent binary program bytes are:

	bit							
	b8	b7	b6	b5	b4	b3	b2	b1
byte 1	Ø	1	Ø	1	1	1	Ø	Ø
byte 2	*	*	Ø	Ø	1	Ø	Ø	*
byte 3	1	*	1	Ø	Ø	Ø	*	*

* these bits should always be Ø

Note that all groups of bits must be programmed to the desired value irrespective of any necessity for updating.

Programming less than three bytes will cause a syntax error.

Binary dump. After being programmed with H the DVM will assemble the current status of the instrument in the identical format to that of binary program. When the controller addresses the DVM to talk, these 3 bytes together with an EOI with the last byte will be output.

NOTE: The three bytes will be overwritten by any commanded reading occurring between the dump command and the output of the result.

Calibration via the bus

The DVM can be calibrated remotely using the programming instructions provided. For full details of procedure see the Calibration and Servicing Handbook.

Invalid use of these instructions will cause the generation of an option error SRQ.

High speed readings

Superfast

Two superfast modes are available, S1 reducing the full range measurement time to approx 10mS. The data both on display and output is reduced to $4^1/_2$ digits with all output modes available. In S2 mode each full range measurement takes approx 5mS the display being replaced by the message SF2 and the output available only in binary format (O2 or O3 modes).

Superfast excludes the use of autorange, and max-min (N3) mode.

Programming SØ will place the instrument into normal operating mode.

Recommendations for use of superfast modes

To achieve the high read rates available in superfast (S1 up to 100 readings/second, S2 up to 200 readings/second) and to output these readings over the bus requires some knowledge of the controller's capabilities.

Responding to SRQ's generated by the DVM at the end of each reading and then outputting the reading as an ASCII string can sometimes introduce intolerable delays into the system. For example... the response to SRQs in some controllers can be as much as 10mS and the subsequent output of a 14 byte ASCII string at around 200 μS per byte limits the maximum reading speed to 78 readings/second.

This problem can be overcome by a combination of techniques. Firstly to use a binary output mode, O2 or O3 which reduces the number of bytes output to four. Secondly many controllers have a fast block transfer mode of operation. In this mode bytes are continually accepted over the bus as they become available (i.e. as the DVM generates new readings) and are stored in a temporary buffer. When the block transfer is complete the data may be read out of the buffer and processed as required.

The DVM requires an external trigger of sufficient frequency (recommended 2kHz) to achieve maximum superfast speeds.

Error readout, Test and Zero.

Error. The programming and execution of code E1 causes the instrument to compute the measurement uncertainty of the previous reading. An SRQ is generated (if allowed) with the status byte indicating a normal valid measurement. The output format is:

1.888E±88PUCrLf (where PU = per unit)

The DVM will be held until EØ is programmed or until a GET or manual trigger is received, assuming the correct trigger mode has been programmed.

Error readout is not avaliable in binary output mode.

Test. When the DVM receives a Y command the internal test routine is initiated. The front panel displays are not exercised in this test and only circuit and calibration memory checks are included. Any error will be reported with the generation of an SRQ together with the appropriate status and an error message made available for output. Programming another Y will continue the test after an error situation. Upon completion an appropriate pass or fail status will be generated with an SRQ, and the DVM will return to the previously programmed range and function, except for max/min, and error readout which will be cleared on completion.

Zero. Z initiates a series of 17 readings at an internal read rate, the first 16 being averaged and the result used as a zero offset. The 17th reading is available for output. If autorange is selected each range is zeroed in turn (lowest to highest). Should the offset be too large, the store is not updated and an SRQ and error status is generated together with an error message for output.

Program string characteristics

If more than 25 bytes have been programmed before receipt of any terminator the execution of the string will commence sequentially until sufficient space is available for further input data.

If an invalid command is sent an SRQ will be generated, the associated status byte containing a syntax error. In this case the output available is '!CrLf'.

NOTE:
1. For program instruction requiring only one numeral after an alpha character, the last numeral is operated on and a syntax error reported.
   e.g. F123 results in F3 (DCV).
2. For all program strings a finite time is required for execution, e.g. the string "R4F3Q1T7 =" will be processed and triggers enabled after approx 15mS from receipt of string terminator.

Bus messages

Remote. The DVM will go to remote when remote enable line (REN) is true and the device receives its listen address. It is possible to send a program string to the DVM when in local which will be acted upon immediately when the DVM goes to remote.

Local. The GTL message returns the DVM to front panel control in the condition in which it was last programmed remotely with the exception of the trigger mode which is forced to T1 and superfast which is cancelled.

Clear. When the instrument receives a clear message (SDC or DCL) it will revert to a predetermined state of DC volts 1000V range and reset.

i.e. CØDXEØF3IØNØOØQØR6SØT1

Operational sequence guidelines

Most interface communication tasks require a sequence of coded messages to be sent over the interface. It is recommended that a careful study of the available controller capabilities is made, many of them assigning one programming instruction to these sequences. Different controllers will not necessarily have identical sequences or program instructions.

It is highly recommended that a sequence which causes the DVM to be addressed as a talker should be terminated with an untalk command.

The following sequences are recommendations only.

Data transfer

UNL	Inhibits all current listeners
LAD_1	Each address sent enables a specific device to receive future data bytes.
LAD_n	More than one address may be sent if multiple listeners desired.
TAD	The address sent enables a specific device to send data.
DAB_1	Data bytes sent by currently enabled talker to all currently enabled listeners.
DAB_n	
UNT	Disables the talker on receipt of last character.

UNL =	unlisten
LAD =	listen address of specific device
TAD =	talk address of specific device
DAB =	data bytes
UNT =	untalk

Serial poll

UNL	Prevents other devices listening to status sent.
SPE	Puts interface into serial poll mode during which all devices send status instead of data when addressed.
TAD_n	Enable a specific device to send status. Within this loop devices should be sequentially enabled.
SBN or SBA	Status byte sent by enabled device. If SBN sent, loop should be repeated. If SBA sent, the enabled device is identified as having sent SRQ and will automatically remove it.
or	
SPD	Disables serial poll mode
UNT	Disable last talker.

SPE =	serial poll enable
SPD =	serial poll disable
SBN =	status byte negative where bit 7 = Ø.
SBA =	status byte affirmative where bit 7 = 1.

Parrallel poll Configure

LAD	Addresses a particular device for which a parallel response coding is to be assigned.
PPC	Enables the listener to be configured.
PPE	Bit 4 specifies the sense of the poll response. Bits 1 to 3 specify, in binary code, the data line (DIO) on which the poll response is to be given.
UNL	End of configuration routine.

PPC =	parallel poll configure
PPE =	parallel poll enable

NOTE: The PPE command can be disabled by substitution of PPD.
All devices can be unconfigured by use of the PPV command.

PPD =	parallel poll disable
PPU =	parallel poll unconfigure

Parallel poll response

To obtain the parallel poll response, the controller must place the management lines ATN and IDY (attention and identify) true when the predetermined devices will each place their request on a specified data line.

SECTION 5 INSTALLATION

This section contains information and instructions for unpacking and installing the Datron 1065 Autocal voltmeter.

Unpacking and inspection

Every care is taken in the choice of packing material to ensure that your equipment will reach you in perfect condition.

If the equipment has been subject to excessive mishandling in transit, the fact will probably be visible as external damage to the shipping carton. In the event of damage, the shipping container and cushioning material should be kept for the carrier's inspection or until the instrument has passed the Specification Verification Tests.

Unpack the equipment and check for external damage to the case, terminals, keys, etc. If damage is found notify the carrier and your sales agent immediately.

Standard accessories supplied with the instrument are as described in Section 1.

The rack mounting kit option is packed separately and should be fitted as instructed in "mounting".

Fuse

The power fuse is located on the left-hand side of the back panel adjacent to the power input. The power fuse rating is 160mA for 205V—255V and 500mA for 105V—127V supply voltages. It should be of the anti-surge type.

MAKE SURE THAT ONLY FUSES WITH THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE ARE USED FOR REPLACEMENT. THE USE OF MENDED FUSES AND THE SHORT-CIRCUITING OF FUSE-HOLDERS SHALL BE AVOIDED, AND RENDERS THE WARRANTY VOID.

Preparation for operation

Power cable

A detachable supply cable, comprising two metres of 3-core PVC sheath cable permanently moulded to a fully-shrouded 3-pin cable socket, fits at the rear of the instrument and should be pushed firmly home. The supply lead should be connected to an earthed outlet ensuring that the earth lead is connected. Connect Brown lead to Live, Blue lead to Neutral and Green/Yellow lead to Earth.

Line voltage

The instrument is packed ready for use with 205V to 255V 50Hz supplies unless Option 80, 81 or 82 is specified at the time of ordering. To change the supplies and/or line frequency, it is necessary to alter links in the instrument. (Refer to Calibration and Servicing Handbook).

Mounting

Bench Use:
The instrument is fitted with rubber covered plastic feet and tilt stand. Thus it may be placed flat on the bench or tilted for ease of viewing.

Rack Mounting:
Option 90 permits the instrument to be mounted in a standard 19 in rack.
The method of fitting this option is described below but on no account should the covers be removed.

The rack mounting 'ears' may be fitted by slotting the 'ears' into the guides at each side of the instrument, from the rear. Draw the 'ears' forward until positioned correctly and tighten the hexagonal screws, using the hexagonal key provided. It is recommended that the rear of the instrument is supported in the rack.

Connectors and pin designations

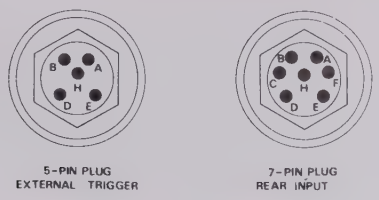


Fig. 5.1 Rear panel connectors - pin layout

Rear input

J11 is a 7-pin connector accepting input signals as defined for the front panel terminals. See Tables 2.1 to 2.3 for maximun. inputs, Table 5.1 for pin descriptions and Fig. 5.1 for pin layout.

Pin No.	Signal
A	Ω GUARD
B	Not Used
C	I+
D	Input Hi
E	Input Lo
F	I--
H	GUARD

Table 5.1 Rear Input - pin designations

NOTE: For local guarding, connect pins A and H.

External trigger input

J9 is a 5-pin connector used to accept an external trigger source to initiate a DVM measurement cycle. See Table 5.2 for pin descriptions and Fig. 5.1 for pin layout.

Pin No.	Signal
A	Trigger (High to Lo edge ↓)
B	Logic Ground
D	Not Used
E	Not Used
H	Not Used

Table 5.2 External Trigger Input - pin designations

IEEE input/output

The IEEE input/output is a 24-way connector that is directly compatible with the IEEE defined system but requires a connection adaptor for the IEC defined system (D-type cannon).

Fig. 5.2 gives the pin designations and Table 5.3 the pin layout.

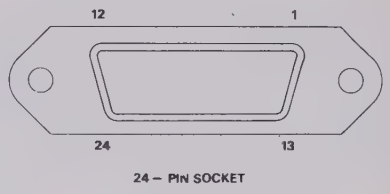


Fig. 5.2 IEEE 488 connector - pin layout

J27 Pin No.	Name	Description
1	DIO 1	Data Input Output Line 1
2	DIO 2	Data Input Output Line 2
3	DIO 3	Data Input Output Line 3
4	DIO 4	Data Input Output Line 4
5	EOI	End of Identify
6	DAV	Data Valid
7	NRFD	Not ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening on cable - connected to DVM logic gnd.
13	DIO 5	Data Input Output Line 5
14	DIO 6	Data Input Output Line 6
15	DIO 7	Data Input Output Line 7
16	DIO 8	Data Input Output Line 8
17	REN	Remote Enable
18	GND 6	Gnd wire of twisted pair with DAV
19	GND 7	Gnd wire of twisted pair with NRFD
20	GND 8	Gnd wire of twisted pair with NDAC
21	GND 9	Gnd wire of twisted pair with IFC
22	GND 10	Gnd wire of twisted pair with SRQ
23	GND 11	Gnd wire of twisted pair with ATN
24	GND	DVM logic ground

Table 5.3 IEEE 488 connector - pin designations

SECTION 6 SPECIFICATIONS

General

POWER SUPPLY

Voltage	:	205-255 or 105-127 Volts
Line Frequency	:	**50Hz ± 2%, 60Hz ± 2%, 400Hz ± 2%**
Consumption	:	Approximately 30VA
Fuses	:	160mA or 500mA anti-surge (depends on voltage)

MECHANICAL

Dimensions	:	Height = 89mm, Width = 455mm, Depth = 420mm
Weight	:	10 kg.

AUTORANGE

Range Up	:	200% of nominal range
Range Down	:	18.8% of nominal range

SAFETY

The 1065 has been designed to meet BSI 4743, IEC 348, and UL 1244 specifications.

MAXIMUM INPUTS

See Tables 2.1 & 2.2

CLIMATE CONDITIONS

Operating Temperature	:	0°C to +50°C (except where specified)
Storage Temperature[1]	:	—40°C to +70°C
Maximum Relative Humidity	:	75% 40°C
Warm-up Time	:	Two hours to meet all specifications

OPERATING INDICATIONS

Scale length	:	Normal	5½ digits i.e. 199,999
		Superfast	4½ digits i.e. 19,999
Overload	:	Err OL displayed	
Indication	:	Symbols lit on display and illuminated keys	

DIGITAL ERROR

Error read-out	:	<1% of displayed error

[1] Excessive temperature stress may affect calibration.

DC VOLTAGE

Full range Count (FR): ± 100,000
Full Scale Count (FS): ± 199,999 on all ranges except 1000V range
Superfast Mode Full Scale Count: 19,999 on all ranges except 1000V range.

ACCURACY

24 HOURS (23°C ± 1°C)	
0.1V range:	± 20ppm of reading ± 3 digits
1 and 10V ranges:	± 15ppm of reading ± 1 digit
100 and 1000V ranges:	± 30ppm of reading ± 1 digit
90 DAYS (23°C ± 5°C)	
0.1V range:	± 60ppm of reading ± 4 digits
1 and 10V ranges:	± 40ppm of reading ± 1 digit
100 and 1000V ranges:	± 70ppm of reading ± 1 digit
1 YEAR (23°C ± 5°C)	
0.1V range:	± 80ppm of reading ± 4 digits
1 and 10V ranges:	± 60ppm of reading ± 1 digit
100 and 1000V ranges:	± 100ppm of reading ± 1 digit

Superfast Mode (all ranges): ± 0ppm of reading ± 2 digits

TEMPERATURE COEFFICIENT: (10°C to 35°C)
1/10th of 90 DAY specification ± 0.2 μV/°C

READ RATE
Normal Mode
All DC ranges: 3/second (internal trigger) with full scale input
30/35 second (external trigger) with full range input at 50/60Hz.
Superfast Mode
All ranges: 200/220 second (external trigger) with full range input at 50/60Hz.

SETTLING TIME (to 10ppm of step size)[1]
Filter out: <5mS
Filter in: < 350mS

SERIES MODE REJECTION
Filter out: 66dB@line frequency
Filter in: 100dB@line frequency

COMMON MODE REJECTION
1kΩ source unbalance
>140dB at DC
> 80dB + series mode at 1Hz to 60Hz

AUTORANGE SPEED (No filter)
Typically 100mS per range between top and bottom ranges.

INPUT RESISTANCE
0.1 to 10 Volt ranges (<20 volts): >10,000 MΩ
100 and 1000 Volt ranges: 10MΩ ± 0.1%.

INPUT ZERO STABILITY (1 year)
<50pA, <5 μV.

RESISTANCE

Full Range Count: 100,000
Full Scale Count: 199,999
Superfast Mode Full Scale Count: 19,999

ACCURACY

24 HOURS (23° ± 1°C)	
100Ω range:	± 25ppm of reading ± 4 digits
1kΩ, 10kΩ ranges:	± 15ppm of reading ± 1 digit
100kΩ range:	± 20ppm of reading ± 1 digit
1000kΩ range:	± 100ppm of reading ± 1 digit
10MΩ range:	± 200ppm of reading ± 1 digit
90 DAYS (23°C ± 5°C)	
100Ω range:	± 60ppm of reading ± 4 digits
1kΩ, 10kΩ ranges:	± 40ppm of reading ± 1 digit
100kΩ range:	± 50ppm of reading ± 1 digit
1000kΩ range:	± 150ppm of reading ± 1 digit
10MΩ range:	± 400ppm of reading ± 1 digit
1 YEAR (23°C ± 5°C)	
100Ω range:	± 80ppm of reading ± 4 digits
1kΩ, 10kΩ ranges:	± 60ppm of reading ± 1 digit
100kΩ range:	± 70ppm of reading ± 1 digit
1000kΩ range:	± 250ppm of reading ± 1 digit
10MΩ range:	± 600ppm of reading ± 1 digit

Superfast Mode: As DC Volts.

TEMPERATURE COEFFICIENT: (10°C to 35°C)
1/10th of 90 DAY specification ± 600μΩ/°C

READ RATE
Normal Mode
All ranges: As DC Volts.
Superfast Mode: As DC Volts.

TYPE
True 4-wire with active guard (automatic 2-wire on the front panel).
Measurement technique is independent of the internal reference voltage.

OPEN CIRCUIT VOLTAGE
<10 volts on all ranges

LEAD RESISTANCE
Up to 10Ω may be tolerated in any or all leads on any range. (Rejection of lead resistance is 80dß on any range).

RESPONSE TIME
Depends on external capacitance and guarding/shielding techniques used.
Generally up to 10kΩ response as DC Volts.
Higher resistances take longer to settle.
OHMS GUARD may be used to guard out stray capacitance

CURRENT THROUGH UNKNOWN (± 1%)
0.1kΩ ranges: 1mA
1kΩ range: 1mA
10kΩ range: 100 μA
100kΩ range: 10 μA
1000kΩ range: 1 μA
10MΩ range: 100nA

OHMS GUARD (rear input only)
Drive Capability: Hi or Lo to OHMS GUARD, 500Ω minimum (up to 10Ω lead resistance)
Guarding Accuracy: See Section 2 - 'Resistance measurement'.

INPUT ZERO STABILITY (1 year)
<10mΩ

[1] Or < 3 digits following a range change.
NOTE: SUPERFAST selected by IEEE digital interface only.

AC VOLTAGE (TRUE RMS)

Full Range Count: 100,000
Full Scale Count: 199.999 on all ranges except 1000V range.

ACCURACY (Signals $<10^7$ Volt Hz $>$ 1.0% Full Scale

	45 Hz [1] to 30k Hz	30k Hz to 100k Hz [2]	100k Hz to 1M Hz [2]
24 HOURS (23°C ± 1°C)			
1V to 1000V ranges:	± 0.04% of reading ± 50 digits	± 0.2% of reading ± 200 digits	± 5% of reading ± 2000 digits
90 DAYS (23°C ± 5°C)			
1V to 1000V ranges:	± 0.6% of reading ± 50 digits	± 0.4% of reading ± 200 digits	± 6% of reading ± 2000 digits
1 YEAR (23°C ± 5°C)			
1V to 1000 ranges:	± 0.1% of reading ± 50 digits	± 0.6% of reading ± 200 digits	± 7% of reading ± 2000 digits

DC coupled AC total accuracy specifications are x 1.5

LF ACCURACY add
Filter out, at line frequency: ± 0.6% of reading
Filter in, 10Hz: ± 2.0% of reading

CREST FACTOR
5:1 typically, at full range

TEMPERATURE COEFFICIENT (10–35°C)
<1/10th of 90 DAY specification/°C

COMMON MODE REJECTION
1KΩ unbalanced > 90dB@DC - 60Hz

READ RATE (as DC voltage)

INPUT IMPEDANCE
1MΩ shunted by 150pF

CONVERSION TYPE
True r.m.s. AC coupled (measures AC component with up to 1000V DC bias on any range) or DC coupled (measures $\sqrt{AC^2 + DC^2}$)

SETTLING TIME (DC coupled)
(i) To 0.1% of step size
Filter out <150mS
Filter in <500mS

(iii) From DC bias input (AC coupled) or severe overload:
Depends on change of DC bias
(Time constant 2.2 seconds)

[1] Read 360Hz instead of 45Hz if 'Filter' not selected.
[2] Error readout invalid above 30kHz.

Standard internal delays

Between the receipt of any trigger pulse and the commencement of a measured cycle, an internal time delay is introduced.

This permits the application of the signal to the input terminals to be coincident with the trigger and ensures that the input circuitry has settled before the commencement of the reading cycle.

The standard internal delays differ for each range and function in order to ensure maximum read-rate and adequate settling. The delays are shown in the following table.

Additional to all the delays shown is 25mS when changing range between 10V and 100V ranges and also before the first reading following a function change.

Function	Range	FILTER OUT (ms)	FILTER IN (ms)
DCV	all	5	500
ACV DC + ACV	all	225	750
kΩ	100Ω -100kΩ 1MΩ 10MΩ	5 15 150	500 600 1250

SECTION 7 SPECIFICATION VERIFICATION

Introduction

The following section is a procedure to check that the instrument is working within its specified accuracy.

After each set of checks is a table of test limits. The period elapsed since the instrument was last recalibrated determines the column to be used for comparison. The tables do not include temperature coefficient corrections and this should be taken into account if the instrument is being checked outside the specified limits.

To record the readings obtained, a Specification Verification Report Sheet is included at the end of this section. This may be used as a permanent record for a 'goods inwards' inspection or routine performance check.

If the instrument is found to be out of specification, reference should be made to the Calibration and Servicing Handbook for a routine calibration or, if necessary, fault finding procedure.

Equipment requirements

DC voltage - a DC source of accuracy at least four times better than the accuracy being verified from 100mV to 1000V.

Example:
Fluke 332D DC Calibrator

AC voltage - Hewlett Packard 745A AC Calibrator + 746A High Voltage Amplifier or Fluke 5200A Programmable AC Calibrator + 5215A Power Amplifier.

Resistance - a set of standard resistors covering 100Ω to 10MΩ . The 100Ω to 10kΩ should be 4-wire type.

1065 DC performance

1. Turn on the instrument to be checked and allow a minimum of 2 hours to warm up in the specified environment.
2. Cancel any 'Mode' keys, select front input and check that 'cal' is not displayed.
3. Select 'Test' and check that the Self Test routine is passed (see Section 3).
4. Connect DC Voltage source and turn down to zero. Allow input to stabilise.
5. Select 'DC', 'Auto', 'Filter' and 'Zero'. When this routine is complete the 'Zero' key LED will be extinguished.
6. Select range 10 and apply the input signals between 'Hi' and 'Lo' as listed in Table 7.1. Check that the displayed reading is within the limits shown in Table 7.1.
7. Select each range in turn and apply a corresponding full range input signal between 'Hi' and 'Lo'. Check that the displayed reading is within the limits shown in Table 7.2.

NOTE: When checking the .1 Volt range it will be necessary to turn the source down to zero and allow the thermal emf's to disappear or stabilise (several minutes). Select .1 range and then 'Zero' to 'zero out' any offset. The signal may then be applied.

If changing polarity involves reversing leads, this procedure may need to be repeated as the thermal emf's may have changed.

1065 AC performance

1. Carry out 1065 DC performance checks 1 to 3 if the DC performance has not been verified.
2. Select 'AC', 'Filter' and each range in turn and apply a corresponding full range input signal between 'Hi' and 'Lo' at the frequencies specified. Check that the displayed reading is within the limits shown in Table 7.3.

1065 resistance performance

1. Carry out 1065 DC performance checks 1 to 3 if the DC performance has not been verified.
2. Connect a true four wire zero as detailed in the section on Resistance Measurement. Select 'k Ω ', 'Filter' and 'Zero'.
3. Carry out step 2 for each range in turn and then measure the corresponding full range resistor. Four wire connection is recommended throughout but a two wire arrangement may be used for 1MΩ and above. If high value standards are fitted with a guard terminal, this should be connected to 'I+'. Check that displayed reading is within the limits shown in Table 7.4.

Range	Input Signal	24 HR Test Limits	90 DAY Test Limits	1 YEAR Test Limits
10	± 1mV	.0009 to .0011	.0009 to .0011	.0009 to .0011
10	± 10mV	.0099 to .0101	.0099 to .0101	.0099 to .0101
10	± 100mV	.0999 to .1001	.0999 to .1001	.0999 to .1001
10	± 1V	.9999 to 1.0001	.9999 to 1.0001	.9998 to 1.0002
10	± 10V	9.9997 to 10.0003	9.9995 to 10.0005	9.9993 to 10.0007
10	± 19V	(1.9 x reading at 10V ± 1 digit)	(1.9 x reading at 10V ± 1 digit)	(1.9 x reading at 10V ± 1 digit)

Table 7.1 1065 DC Linearity Checks [1]

Range	Input Signal	24 HR Test Limits	90 DAY Test Limits	1 YEAR Test Limits
.1	± 100mV	99.995 to 100.005	99.990 to 100.010	99.988 to 100.012
1	± 1V	.99997 to 1.00003	.99995 to 1.00005	.99993 to 1.00007
10	± 10V	9.9997 to 10.0003	9.9995 to 10.0005	9.9993 to 10.0007
100	± 100V	99.996 to 100.004	99.992 to 100.008	99.989 to 100.011
1000	± 1000V	999.96 to 1000.04	999.92 to 1000.08	999.89 to 1000.11

Table 7.2 1065 DC Full Range Checks [1]

Range	Input	Frequency	24 HR Test Limits	90 DAY Test Limits	1 YEAR Test Limits
1	1V	500Hz	.99910 to 1.00090	.99890 to 1.00110	.99850 to 1.00150
1	1V	40kHz	.99600 to 1.00400	.99400 to 1.00600	.99200 to 1.00800
10	10V	500Hz	9.9910 to 10.0090	9.9890 to 10.0110	9.9850 to 10.0150
10	10V	40kHz	9.9600 to 10.0400	9.9400 to 10.0600	9.9200 to 10.0800
100	100V	500Hz	99.910 to 100.090	99.890 to 100.110	99.850 to 100.150
100	100V	40kHz	99.600 to 100.400	99.400 to 100.600	99.200 to 100.800
1000	1000V	500Hz	999.10 to 1000.90	998.90 to 1001.10	998.50 to 1001.50
1000	1000V	20kHz	996.00 to 1004.00	994.00 to 1006.00	992.00 to 1008.00

Table 7.3 1065 AC Full Range Checks [1]

Range	Resistor Value	24 HR Test Limits	90 DAY Test Limits	1 YEAR Test Limits
.1	100Ω	99.993 to 100.007	99.990 to 100.010	99.988 to 100.012
1	1kΩ	.99997 to 1.00003	.99995 to 1.00005	.99993 to 1.00007
10	10kΩ	9.9997 to 10.0003	9.9995 to 10.0005	9.9993 to 10.0007
100	100kΩ	99.997 to 100.003	99.994 to 100.006	99.992 to 100.008
1000	1MΩ	999.89 to 1000.11	999.84 to 1000.16	999.74 to 1000.26
10MΩ	10MΩ	9.9979 to 10.0021	9.9959 to 10.0041	9.9939 to 10.0061

Table 7.4 1065 Resistance Full Range Checks [1]

[1] All test limits are relative to the calibration standards.

SPECIFICATION VERIFICATION REPORT SHEET

DATRON MODEL ..... DATE .....

SERIAL NUMBER ..... TESTED BY .....

1. (a) DC VOLTS

Linearity Check

Range	Input Signal	Reading + Polarity	Reading – Polarity
10	1mV		
10	10mV		
10	100mV		
10	1V		
10	10V		
10	19V		

1. (b) DC VOLTS

Full Range Check

Range	Input Signal	Reading + Polarity	Reading – Polarity
.1	100mV		
1	1V		
10	10V		
100	100V		
1000	1000V		

2. AC VOLTS

Full Range Check

Range	Input Signal	Reading 500Hz	Reading 40kHz
1	1V		
10	10V		
100	100V		
1000	1000V		(20kHz)

3. RESISTANCE

Full Range Check

Range	Resistor Value	Reading
.1	100Ω	
1	1kΩ	
10	10kΩ	
100	100kΩ	
1000	1MΩ	
10MΩ	10MΩ	

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